

An Energy Efficiency Workshop & Exposition

Kansas City, Missouri

Case Study: Analysis of Alternative Integrated Building Systems

SmithGroup

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Outline of Presentation

- Background
- Analysis & Methodology
- q Results
- Additional
- conclusion

	Table 6														
	Initial Investment Costs - Mechanical														
	Overhead Air Distribution; Location - Yerevan, Armenia							rmenia							
										1.0	Mate	rial			
					Tal	ole 7					ubtotal	Sh	ipping		Total
		- 1	Init	ial Investme	ent	Costs - I	Vlec	hanical				-			
	_ Undo	erfloo	r Ai	ir Distributi	on;	Location	1 - Y	erevan,	Ar	menia					
Considera						Mate	rial				9,880	\$	1,976	\$	11,856
	1										8,680	\$	1,736	\$	10,416
COMMISSION	LLI				١						2,480	\$	496	\$	2,976
Item	Qwamtiity	Umit	U	Jmit Price	201	ubtotal	2 m	ııbbımg	_	lotal				\$	_
E 0-1111-1-101-101	17			4 445 00	-	10.055		0.704		00.740	9,390		1,878	\$	11,268
Fan Coil Unit, 1/2 ton	17	ea	\$	1,115.00	\$	18,955	\$	3,791	\$	22,746	9,540		1,908	\$	11,448
3/4 ton	3		\$	1,345.00	\$	4,035	\$	807	\$	4,842	4,770		954		5,724
2-ton	1 1	ea	\$	2,100.00	\$	2,100	\$	420	\$	2,520	1,640		328		1,968
Ductwork, Galvanized steel, incl. fittings	4700		\$	0.40		1,880	\$	376	\$	2,256	2,600				3,120
Branch Ductwork, Int., Galv. Stl., incl. Fittings	630	lbs	\$	0.40		252	-	50	\$	302	920		184	\$	1,104
Insulation, ductwork w/vapor barrier	3250	sf	\$	0.23		748	\$	150	\$	897	1,366		273		1,639
Piping, Copper, Type L, 3/4" diameter	660	If	\$	2.07	\$	1,366	\$	273	\$	1,639	1,249		250	\$	1,498
1" diameter	550	If	\$	2.27	\$	1,249	\$	250	\$	1,498	153 692		31 138		184 830
1-1/4" diameter	40	If	\$	3.83	_	153	\$	31	\$	184	1.163		233	\$	1.395
Fittings, copper@ 25%					\$	692	\$	138	\$	830	619		233 58		677
Piping, Sch 40 PVC, Cond. Drain, 1" dia.	350	If	\$	3.19	\$	1,117	\$	223	\$	1,340	239		48		287
Fittings, PVC@ 25%		1.6			\$	279	\$	56	\$	335	60		12		72
Piping, Sch 40 Steel, welded	250	If	\$	4.65	\$	1,163	\$	233	\$	1,395	- 00	Ψ	12	\$	
Fittings, steel@25%			-		\$	619	\$	124	\$	743	1,723	Φ.	345	\$	2.067
Insulation, fiberglass, 1-1/2 thick			-		-		-		\$		1,720		316		1.894
3/4" diameter	680	lf	\$	2.61			\$	355	\$	2,130	124		25		148
1" diameter	600	lf	\$		\$	1,722	\$	344	\$	2,066	585		117	\$	702
2" diameter	250	lf	\$	3.52		880	\$	176	\$	1,056	1.002	\$	200	\$	1.203
Fittings@ 25%			S	4.740.00	\$	1,094 4,740	\$	219 948	\$	1,313	9,525		1.905	\$	11,430
AHU, Const. Vol., Chilled Water, 17 tons	1	ea	-				-		-	5,688	3,600		720	\$	4,320
Boiler, Oil-fired, 200 MBH	1	ea	\$	2,775.00		2,775	\$	555	\$	3,330	2,700	\$	540	\$	3,240
Pump, HW Secondary, 20 GPM	2	ea	\$	1,350.00		2,700	\$	540	\$	3,240	980	\$	196	\$	1,176
Pump, HW Circulating, 20 GPM	1		\$	980.00	\$	980	\$	196	\$	1,176	37,400	\$	7,480	\$	44,880
Chiller, Packaged, Air-cooled, 17 tons	2	ea	\$	14,830.00	\$	29,660	\$	5,932	\$	35,592	3,150		630	\$	3,780
Pump, CHW, 41 GPM	2		\$	1,575.00	\$	3,150	\$	630	\$	3,780	4,752				5,702
Heat Pipe System w/associated controls	1	Is	\$	4,500.00	\$	4,500	\$	900	\$	5,400	1,518	\$	304	\$	1,822
Floor Diffusers Under Floor Leak Detection System	90		\$	75.00	\$	6,750	\$	1,350	\$	8,100				\$	_
	48	_	\$	100.00	\$	4,800	-	960	\$	5,760	_	_		\$	_
Thermostat	1 1	ea	\$	46.00	\$	46	\$	9	\$	55	-	\vdash		\$	
Controls	1	Is	-		-		-		\$		-			\$	-
Balance FCU Unit	22	ea	\vdash		\$		-		\$		1				
Balance Air Handling Unit	1	ea	\vdash		\$	-	-		\$		1				
Balance Air-Cooled Chiller	2		\vdash		\$	-	-		\$		1				
Balance Pump	5	ea	1		\$	-			\$	-	I				



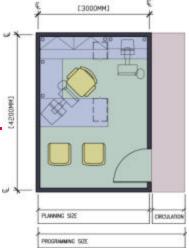
Background - Definitions

- q A/FBO: Foreign Buildings Office
- AEDG Architecture and Engineering Design Guidelines for U.S. Diplomatic Buildings
- SDS Standard Delivery System
- **q** STM Serviceability Tools & Methods
- ABSIC Advanced Building Systems Integration Consortium



Background





- Substantial expansion in new building program since
 1998 aimed at improving Safety & Comfort of occupants
- SDS developed to streamline & effectively manage the project delivery process
- SDS aims to integrate & standardize appropriate levels of Design Criteria & Performance Requirements into the procurement process (AEDG, STM, Perspective™)
- Turned to ABSIC and CMU for academic assessment of current trends in workplace design criteria

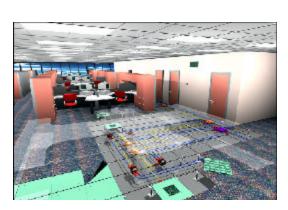




Background-Performance Criteria

- Flexibility: De-mountable partitions, modular furniture, ambient task lighting
- Technology Ready: Modular voice, data and power distribution systems, plug & play capability
- Personal Comfort: Thermal zoning no more than one enclosed or three open offices
- ➤ **Improved IAQ**: ASHRAE Std 62-99
- > **Energy Efficiency:** 10 CFR 435, ASHRAE 90.1-99
- Life Cycle Cost Effectiveness



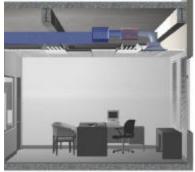




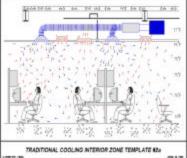
Analysis & Methodology

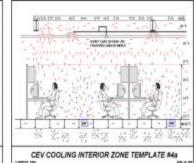
q Analysis

- Life-cycle cost (LCC) based analysis
- Two system concepts conventional (ceilingbased) and floor-based
- Objective to help FBO determine whether a specific system concept should be incorporated into SDS











Analysis & Methodology

q Methodology

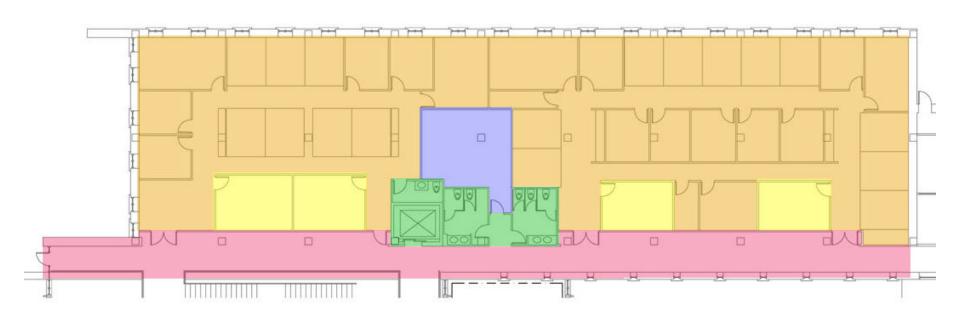
- Space Model
- Loads Model
- System Model
- Plant Model
- Economic Model



Courtesy of York Int'l



Methodology - Space Model



- Mechanical Equipment Room
- Core
- Conference Room

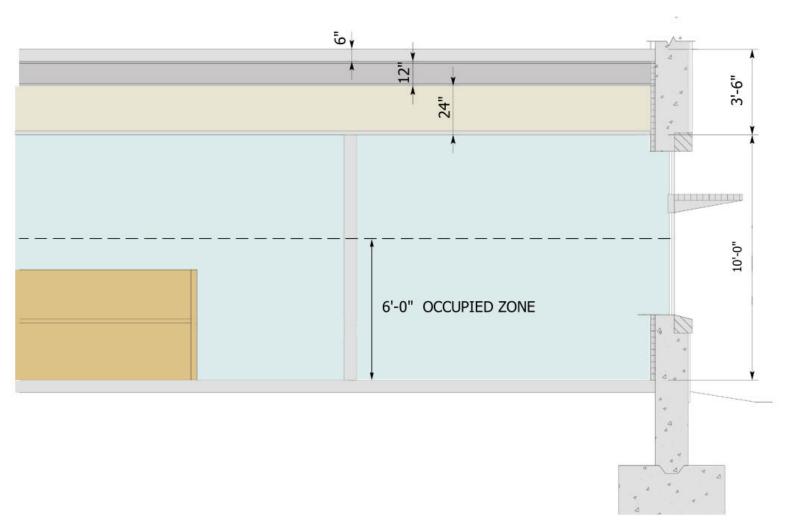
Office

Primary Circulation

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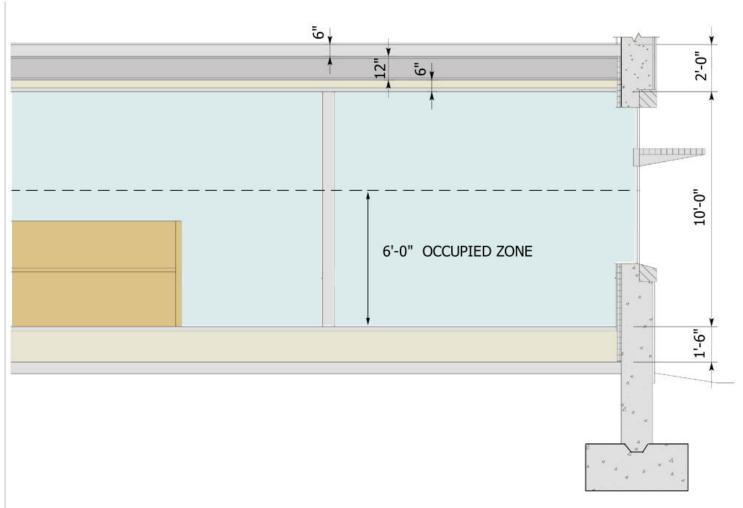


Methodology - Space Model



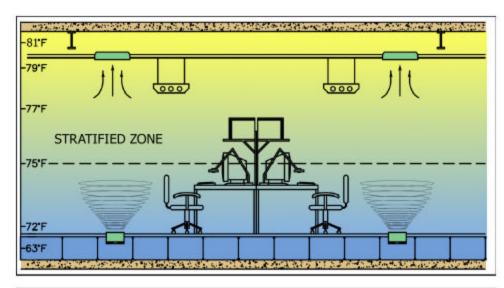


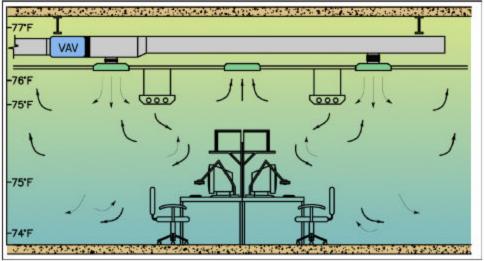
Methodology - Space Model





Methodology - Loads Model







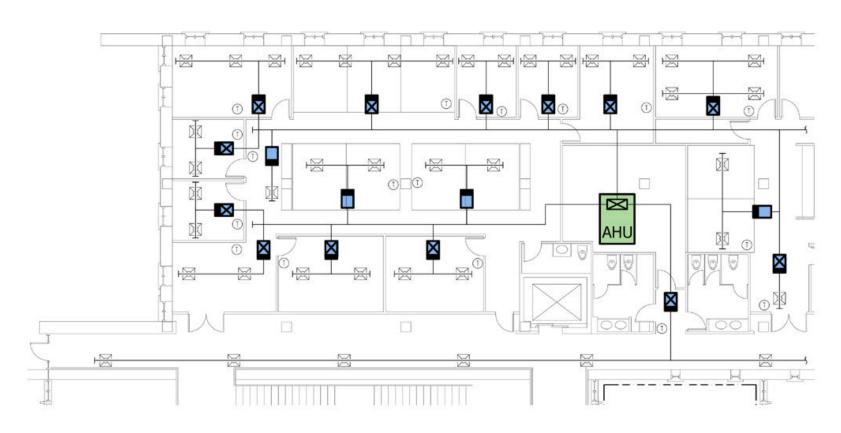
Methodology - Loads Model

Space Loads Comparison

Load Item	Conventional	Floor Based
Lights	18.8 (100%)	<u>11.5</u> (61%)
People	4.6 (100%)	3.3 (70%)
Plug Loads	26.8 (100%)	<u>18.8</u> (70%)
Glass Solar	5.2 (100%)	3.6 (100%)
Glass Conduction	2.3 (100%)	1.6 (100%)
Wall Conduction	2.7 (100%)	1.9 (100%)

(W/sq.m)

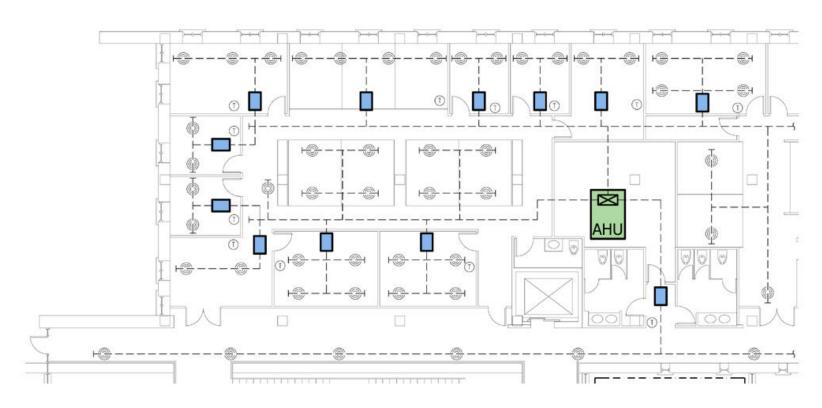




LEGEND

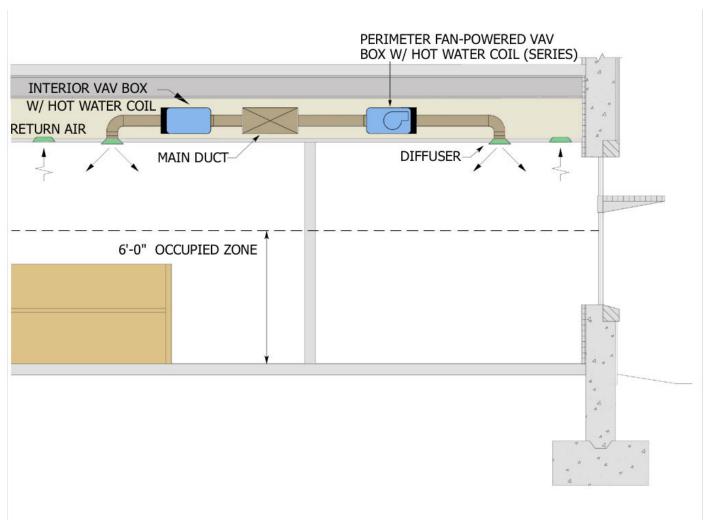
- VAV BOXES WITH REHEAT
- SERIES FAN POWERED VAV BOXES



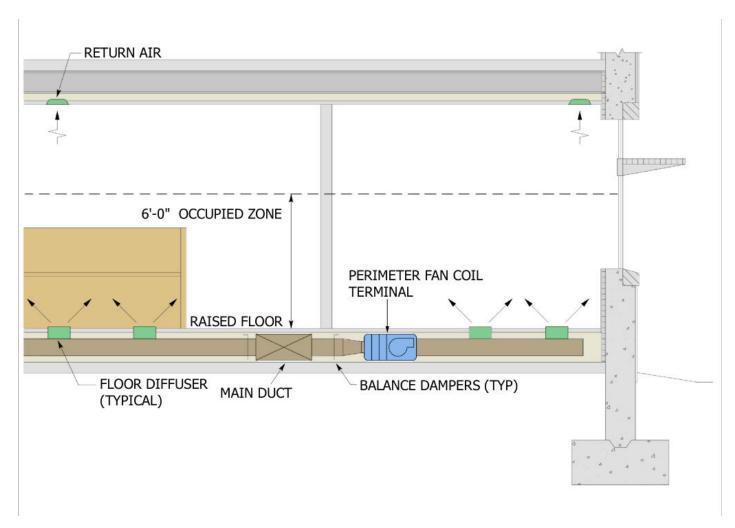








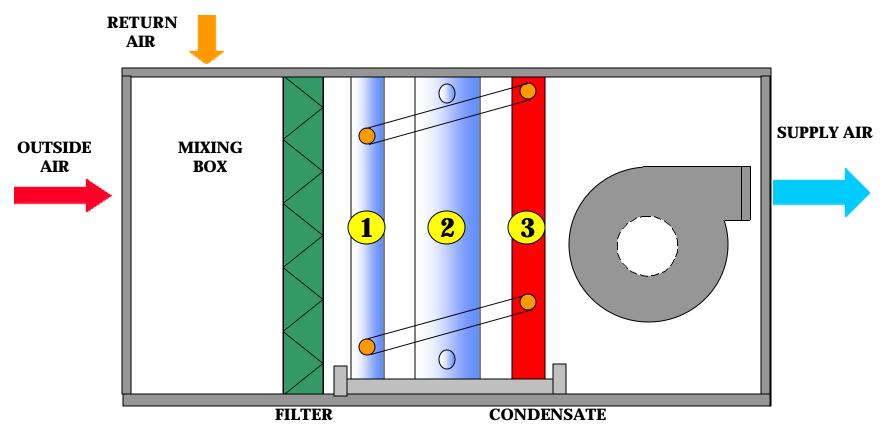






- Central plant common to both
 - > Air-cooled chiller
 - Dual-fuel hot water boiler
- Floor-based AHU required modification to meet indoor design conditions
 - Sub-cooling and re-heating
 - Face and bypass cooling coil
 - Series heat recovery (runaround coils or heat pipes)



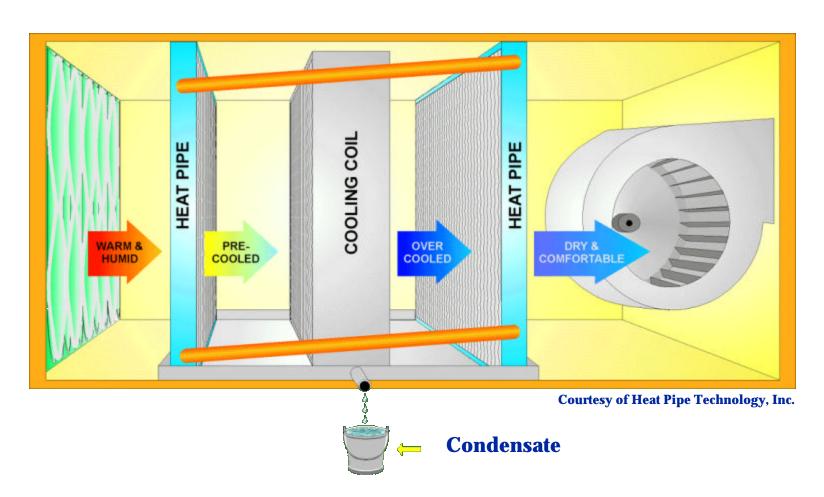


- 1 ENERGY RECOVERY PRE-COOLING COIL
- **3** ENERGY RECOVERY REHEAT COIL

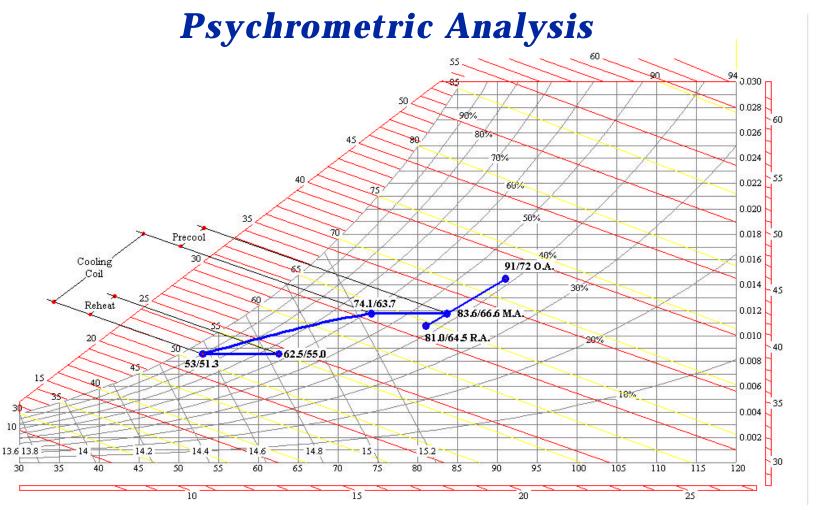
2 COOLING COIL

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Results - Energy Analysis

Equipment Capacity Comparison

Item	Conventional	Floor Based
OA Airflow	1,910 cfm	1,895 cfm
OA Percent	21%	27%
Tot. Airflow	9,090 cfm	7,020 cfm
Cooling Load	24.3 tons	16.9 tons
Heating Load	253 Mbh	233 Mbh
Annual Energy	260,000 kWh	123,000 kWh



Results - Economic Analysis

- Costs developed using U.S. based cost estimates
- Material costs increased by 20% to account for overseas shipping
- Installation costs increased by 50% to reflect exported U.S. labor
- Utility rates based on Mid-Atlantic region
- Discount and fuel escalation rates based on DOE forecasts
- LCC analysis performed using NIST BLCC program



Results - Economic Analysis

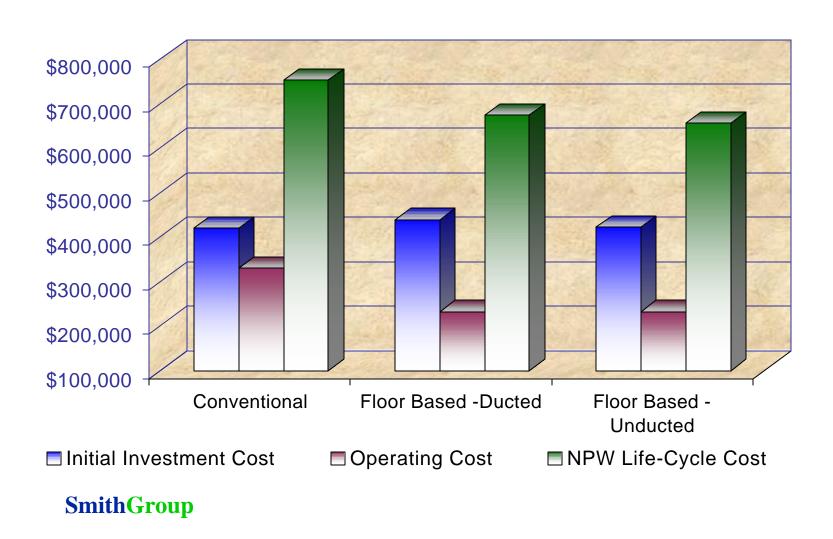
First Cost Comparison

Item	Conven	ional Floo	Based		
		Duc	cted Un-		
	duc	ted			
Raised Floo	r -	\$74 /sm	\$74 / sm		
Carpet	\$14/sm	-	-		
HVAC	\$336/ sm	\$279 / sm	\$253 / sm		
Electrical	\$71 / sm	\$87 / sm	\$95 / sm		
Total*	\$421 / sm	\$440 / sm	\$422 / sm		

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Results - LCC Comparison





Results - Economic Analysis

Life Cycle Cost Comparison

Item	Conven	ional Floor Based		
		Du	cted Un	
	duc	ted		
Initial	\$420,830	\$440,000	\$422,653	
Operation	\$16,101	\$9,962	\$9,962	
Maintenan	ce \$4,607	\$4,742	\$4,742	
NPW	\$751,528	\$673,335	\$656,078	
Svngs/Ini	t'l -	4	52	

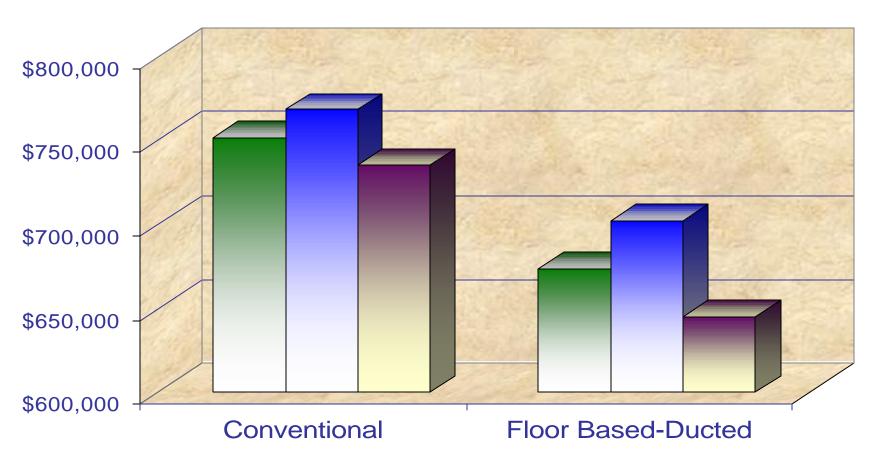
Spl. Payback SmithGroup

3.1 yrs

0.3 yrs



Results - Sensitivity Analysis



■ Base = +10% Initial \$, -10% Energy \$ = -10% Initial \$, + 10% Energy \$

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Additional Considerations

q Productivity



The LEEDTM Rating System



q Flexibility and churn



Additional Considerations - Churn

Churn Cost Data

BOMA 1998 Experience Exchange Report

Simple moves to and from existing workplacesAverage cost\$191 per move

Moves that include the relocation of furniture
 Average cost
 \$712 per move

Moves that require constructionAverage cost\$2100 per move

q IFMA Benchmarks II Survey:

□ Average cost = \$1063 per employee (\$54/sq.m)

□ 41% of employees are relocated every year (\$22/sq.m-yr.)

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Additional Considerations - Churn

Estimated Churn Costs per Sq.m. of affected area

Item		Traditional	Floor Based	Savings
Electrical	Material	\$9.8	\$2.8	\$7
	Labor	\$8.5	\$0.0	\$8.5
	Total	\$18.3	\$2.8	\$15.5
Voice/Data	Material	\$5.6	\$3.2	\$2.4
	Labor	\$5.1	\$0.0	\$5.1
	Total	\$10.7	\$3.2	\$8.5
HVAC	Material	\$11.5	\$0.9	\$10.6
	Labor	\$13	\$0.0	\$13
	Total	\$24.5	\$0.9	\$23.6
Total		\$53.5	\$6.9	\$46.6

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Review Comments



- Concerns with slab condensation in raised floor applications
- Smoke detection in raised floor plenum
- Ability to detect water under floor
- Maintenance and cleanliness of air distribution system
- Floor drains for accidental sprinkler system discharge
- Space temperature gradient
- Seismic Consideration



Conclusion

Summary of results

Overhead alternative: Slightly lower initial cost



Floor based distribution:



- Lower life cycle cost
- Better IAQ and ventilation effectiveness
- Flexible and easy to change by space occupant
- Recognized by USGBC as "Green"
- More comfortable than traditional systems



Conclusion

q Key Considerations

- Perform similar analysis to gauge the influence of performance criteria, "spec office" or "build to suit"
- Integrate raised floor plenum (12-18 inch) without increasing overall building height
- Right sizing of HVAC equipment, assignment of space and coil loads
- Monitor supply air temperature and Relative Humidity
- Special attention to perimeter & Assembly spaces (FPVAV, VAVRH, MZ,fan coil)
- Building Construction: slab and building envelope





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Kansas City, Missouri

Thank You!!!

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